# Coast to Cactus Weather Examiner

National Weather Service - San Diego

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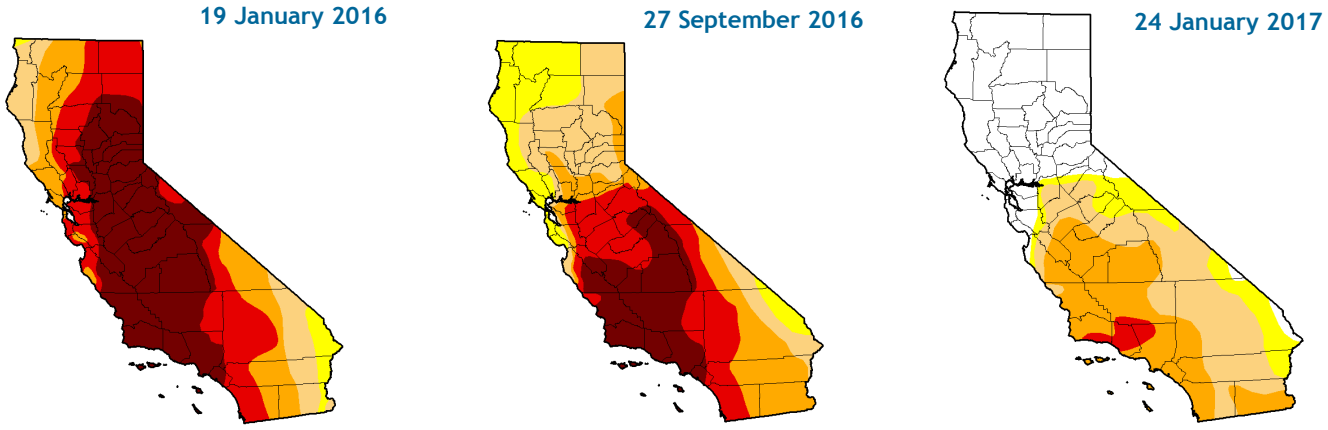
## A Big Dent in the Drought by Miguel Miller

The copious rains of December and January this winter have undoubtedly put a big dent in California's unprecedented drought. At least one respected scientist has even asserted the drought is over. However, the following points are important to remember before calling off the great California drought:

- The Governor's office is the entity that declares when California is or is not in a drought.
- While these systems are bringing good rain and snow, we are only halfway through our water year, and anything can happen.
- Snow pack has improved and is great for this time of year. However, we need it to stay and continue to build through April 1.
- There have been some drought improvements in northern portions of the state, but the state as a whole is still in a drought.
- These January storms, while beneficial, are coming at a rate where it's too much too fast. This is resulting in flooding.
- Much of the rainfall is "running off" due to already saturated soils, and not adequately recharging aquifers/groundwater storage.
- The deficits reflected in local reservoirs and ground water indicate there is still considerable precipitation needed to end the

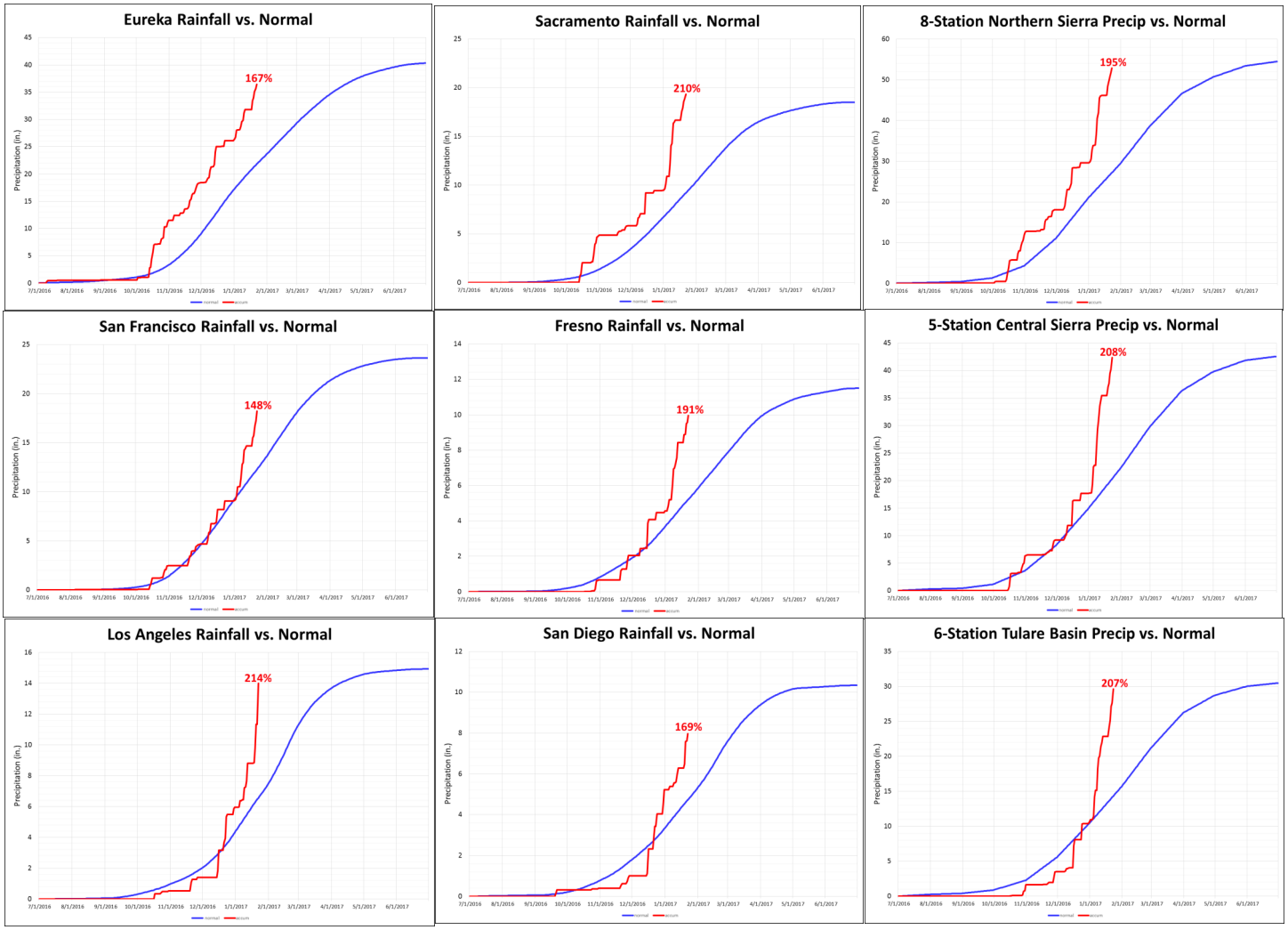
## Inside this issue:




The U.S. Drought Monitor's depiction of drought in California from January 2016 (left), to the beginning of the water year in late September (center) to the current state of drought as of 24 January (right). The recent storms of 19-23 January were taken into account.

# A Big Dent in the Drought—continued

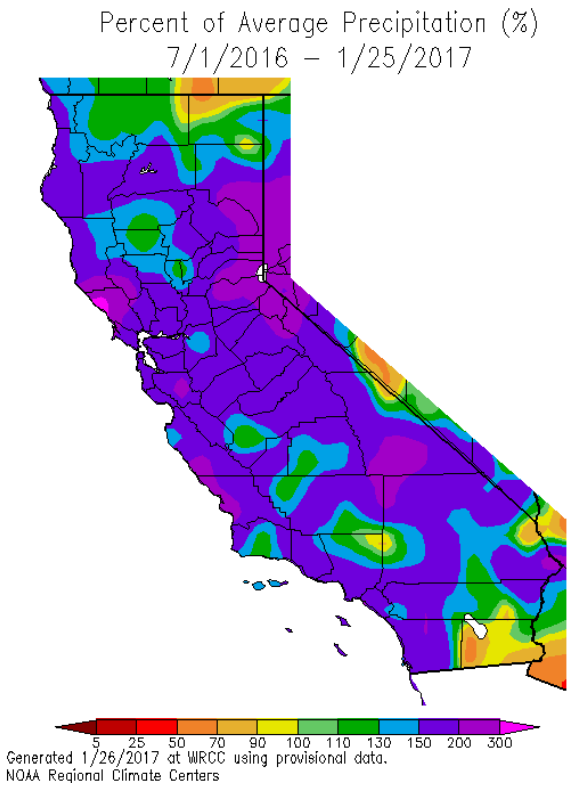



drought. The good news is that an average February and March could bring our seasonal totals well above normal which is needed to make large improvement.

- Historical warmth in the last few years has increased water demand and has increased evaporation of water stores

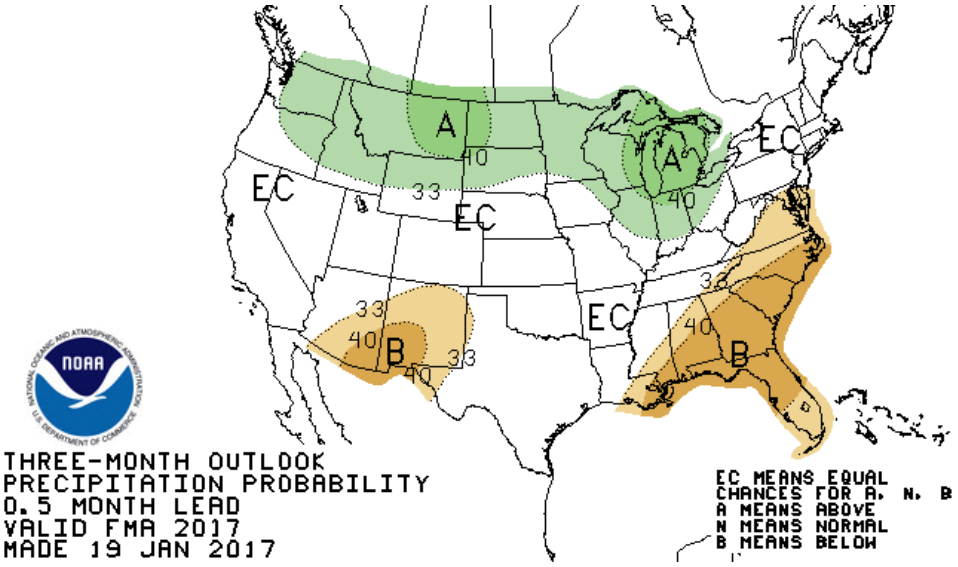
So we can't say yet if the drought is over. But we can watch the U.S. Drought Monitor, and track the rainfall with respect to average across the state. A great [discussion on western drought] is found at: **climate.gov**.

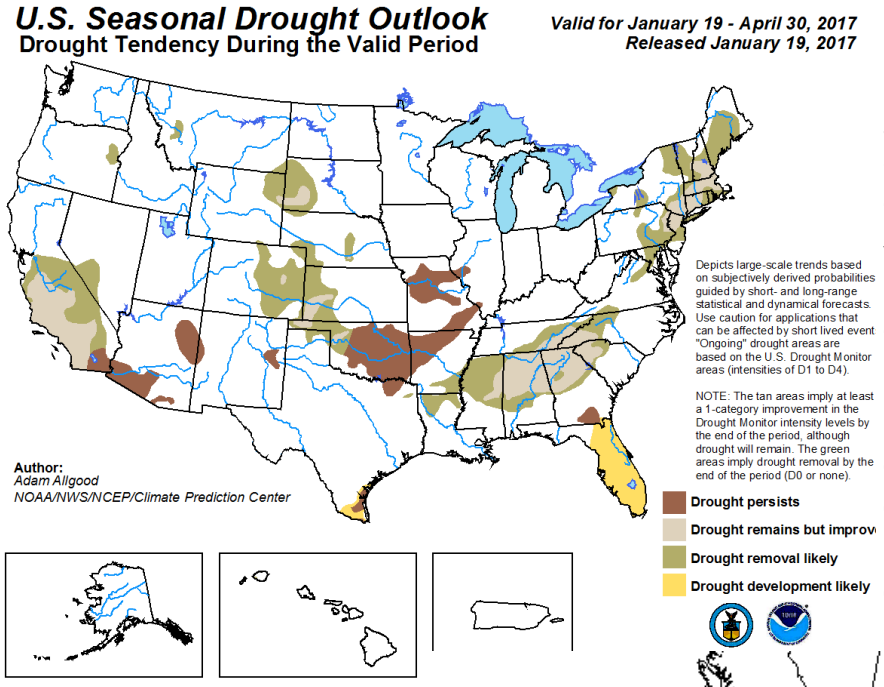
The charts above show the cumulative rainfall since 1 July for select stations across the state. A few stations have already exceeded a normal season's worth of rainfall only halfway through the wet season. The map at right depicts the current situation graphically. Nearly the entire state is well above average and some spots are double or even close to triple the average for this time of year.



## Outlook for the Rest of Winter and Early Spring

The Climate Prediction Center (CPC) released their latest three monthly outlooks on 19 January. With a weak La Niña currently forecast to disappear altogether in February, there isn't much ENSO signal to help forecasters nail down a confident outlook for February, March and April (at right). Consequently, the rest of the winter and early spring in California looks largely undetermined

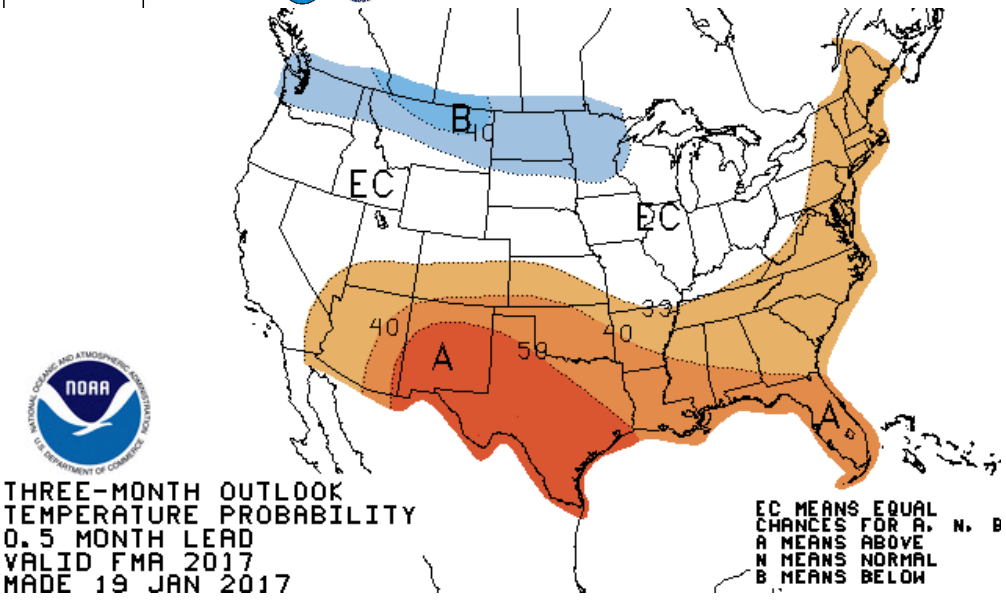



in the precipitation category.

The Drought Outlook for mid-January through April 2017 (at left) shows a lot of improvement in California and in the Southeast, but development in Florida. It's important to note this outlook was released before two to 12 inches of precipitation fell in Southern California from 19-23 January, so some of that forecast improvement may have already occurred.

The three month temperature outlook (below) appears relatively confident that temperatures will be above normal in the Southwest, and less so in the East. Some tilt in the odds toward cooler weather is indicated for the far north. A big swath of country from the West Coast to the Great Lakes has a no-skill forecast and is undetermined.



# It Takes Two to Tango by Derek Schroeter

## How the Pacific *and* the Arctic can Impact California's Water Supply

The freeze-up season (September – March) in the Arctic has been exceptionally strange this year with actually a period of melting occurring shortly after the Winter Solstice (Figure 1) and currently Arctic Sea ice extent is the lowest for this time of year in the satellite record. Since the start of the 21st century the Arctic has been warming at alarming rates exceeding more than double the warming rate of the entire Earth, leading to rapid loss in sea ice. This rapid warming of the Arctic has been called Arctic Amplification and involves a positive feedback mechanism in that with less sea ice, less solar radiation is reflected back into space and more solar radiation is absorbed by the ocean surfaces, leading to more warming. Recently, the possible impacts of less sea ice and a rapidly warming Arctic on weather patterns in the heavily populated mid-latitudes has become a focal point of climate research.

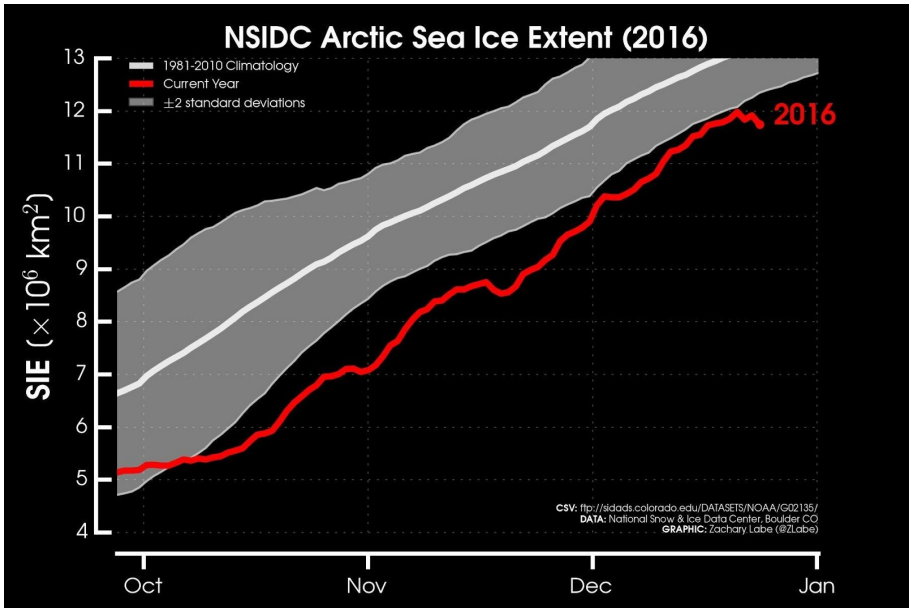



***Figure 1**. Arctic sea ice extent (SIE) showing that the areal extent of sea ice declined briefly around the Winter Solstice. Data from the National Snow and Ice Data Center in Boulder, CO and graphic developed by Zachary Labe.*

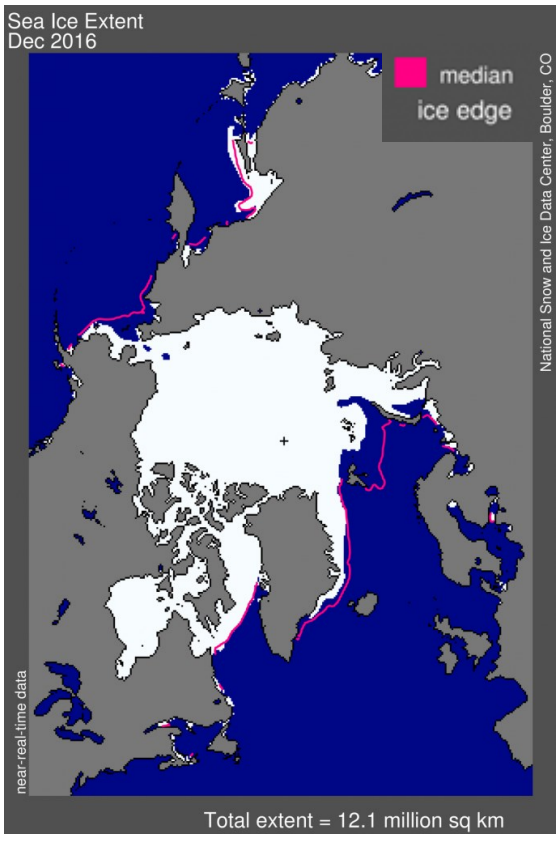



***Figure 2**. Areal extent of sea ice compared to the median ice edge. Notice much of the Bering Sea is ice free as of December 2016.*

The two main pathways in which Arctic Amplification may be impacting mid-latitude weather patterns are through enhancing and expanding upper level high-pressure systems and causing the jet stream to become wavier. Similar to how ice melting in a drink cools the surrounding liquid – albeit less intuitive – freezing of Arctic Sea ice warms the surrounding environment including the atmosphere directly above the ocean-ice interface. This process coupled with warmer than normal ocean surfaces help to amplify ridges of high pressure. Some research has suggested that the exceptionally warm Arctic and less sea ice in the Pacific sector of the Arctic along with warmer than normal sea surface temperatures in the northeast Pacific may be responsible in amplifying the ridge of high pressure that deflected storms away from California during the wet seasons of 2013-14 and 2014-15. Additionally, the

## It Takes Two to Tango—continued

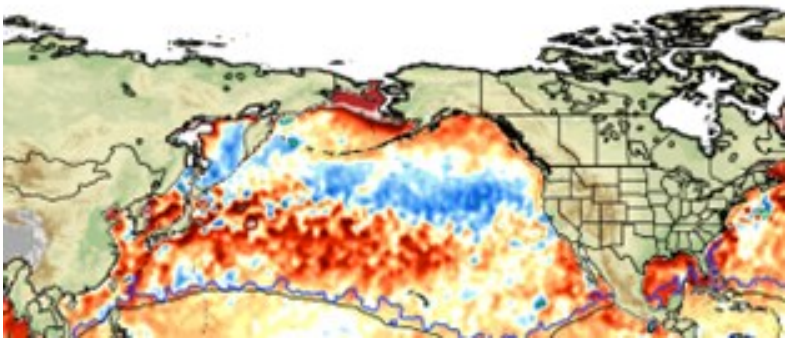


*Figure 3. Sea surface temperature anomalies for the beginning of January 2017. Notice the higher than normal sea surface temperatures in the Bering Sea and the lower than normal sea surface temperatures in the northeast Pacific.*

fundamental driver of the jet stream that brings storms to the west coast is the difference in temperature between the equator and the North Pole. Therefore, under Arctic Amplification this temperature gradient is much weaker causing the jet stream to take on a wavier pattern as opposed to a stronger zonal west to east pattern.

The "It Takes Two to Tango" hypothesis was developed last year by climate scientist Dr. Jennifer Francis and suggests that the pattern of sea surface temperature anomalies in the Pacific sets the stage and the warmer, less ice covered Arctic can help amplify the pattern. This year has featured three important anomaly patterns, which most likely played a role in delivering a deluge of storms into California the first half of January. One: normally much of the Bering Sea is ice covered by this time of year, but inspection of figure 2 shows otherwise. Two: sea surface temperatures in the Bering Sea are well above normal at the start of January (figure 3). Three: unlike previous winters the sea surface temperatures in the northeast Pacific are lower than normal (figure 3). These areas of below normal ice extent/above normal sea surface temperatures in the Bering Sea correspond well with the ridge of high pressure in this region depicted in figure 4. This area of high pressure along with the colder than normal sea surface temperatures in the northeast Pacific has allowed for a trough of low pressure near the west coast (figure 4) to amplify and bring the onslaught of Pacific storms into California.

It is important to note that the study of Arctic Amplification and mid-latitude weather is still very young and the role the Arctic plays in modulating mid-latitude weather is still debated. The problem for climate scientists is that the period of record for Arctic Sea ice extent is too short to detect a robust statistical signal and many studies rely on climate models that produce conflicting results. While it will probably be several more years until climate scientist are able detect a robust Arctic signal in the chaotic climate system, it is the author's opinion that looking to the Arctic will be important for future seasonal forecasts.

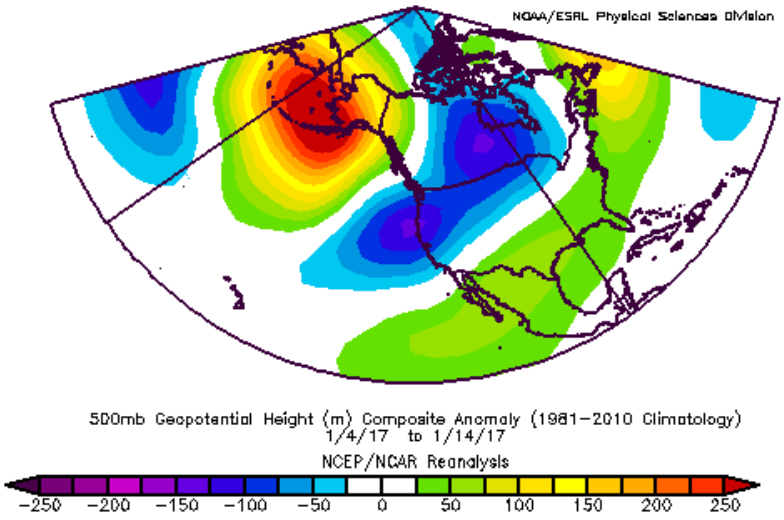



*Figure 4. Map of geopotential height anomalies, which correspond to ridges of high pressure and troughs of low pressure. Notice the positive anomalies over the Bering Sea, which correspond to a strong ridge of high pressure and the negative anomalies over the west coast, which correspond to a trough of low pressure.*

## Newly Launched Satellite to Improve Forecasts adapted from NOAA story

On November 19, 2016 GOES-R, the first of NOAA's highly advanced geostationary weather satellites, lifted off from Cape Canaveral, Florida. The satellite will boost the nation's weather observation network and NOAA's prediction capabilities, leading to more accurate and timely forecasts, watches and warnings.

In December, the satellite reached its orbit, and was officially named GOES-16. Within a year, after undergoing a checkout and validation of its six instruments, the new satellite will become operational.

**GOES-R blasts off from Cape Canaveral, Florida, on 19 November 2016.** *Photo NOAA.*

"The next generation of weather satellites is finally here. GOES-R is one of the most sophisticated Earth-observing platforms ever devised," said NOAA Administrator Kathryn Sullivan. "GOES-R's instruments will be capable of scanning the planet five times faster and with four times more resolution than any other satellite in our fleet. With these new instruments and powerful new capabilities, GOES-R will strengthen NOAA's ability to issue life-saving forecasts and warnings and make the United States an even stronger, more resilient Weather-Ready Nation."

GOES-R (now GOES-16) will scan the skies five times faster than today's GOES spacecraft, with four times greater image resolution and three times the spectral channels. It will provide high-resolution, rapid-refresh satellite imagery as often as every 30 seconds, allowing for a more detailed look at a storm to determine whether it is growing or decaying.

GOES-16 data will help improve hurricane tracking and intensity forecasts, the prediction and warnings of severe weather, including tornadoes and thunderstorms. Additionally, GOES-16's improved rainfall estimates will lead to more timely and accurate flood warnings. "We are ready to receive and process GOES-R data into our forecasts as soon as it is available," said NOAA National Weather Service Director Louis W. Uccellini. "Forecasters will not only have sharper, more detailed views of evolving weather systems, they will have more data – better data – ingested into our weather models to help us predict the weather tomorrow, this weekend and next week. This is a major advancement for weather forecasting."

For the aviation sector, GOES-16 will deliver clearer views of clouds at different atmospheric levels, generating better estimates of wind speed and direction and improved detection of fog, ice and lightning. This will improve aviation forecasts and flight route planning to avoid hazardous conditions such as turbulence.

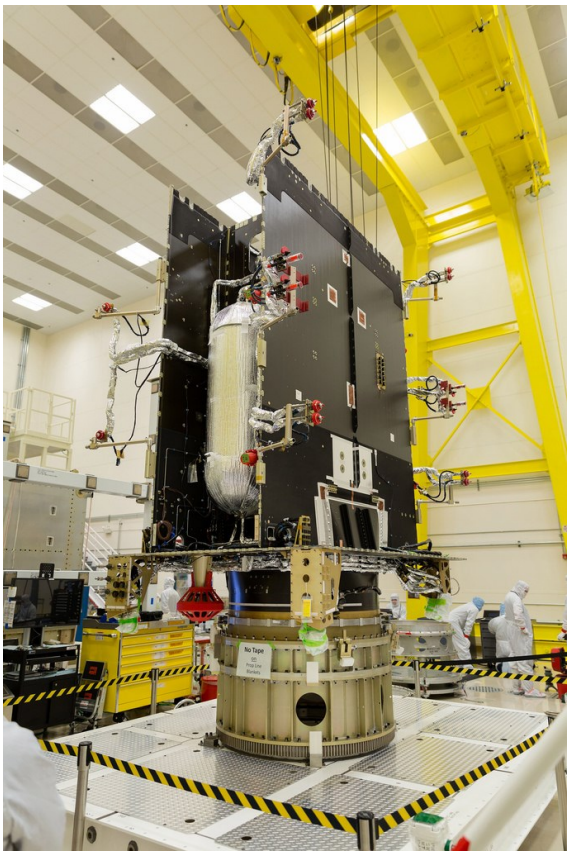
"GOES-R will significantly improve the ability of emergency managers across America to prepare for, and respond to, weather-related disasters. Better situational awareness will result in better outcomes -- from where to best position resources ahead of a storm to delivering more

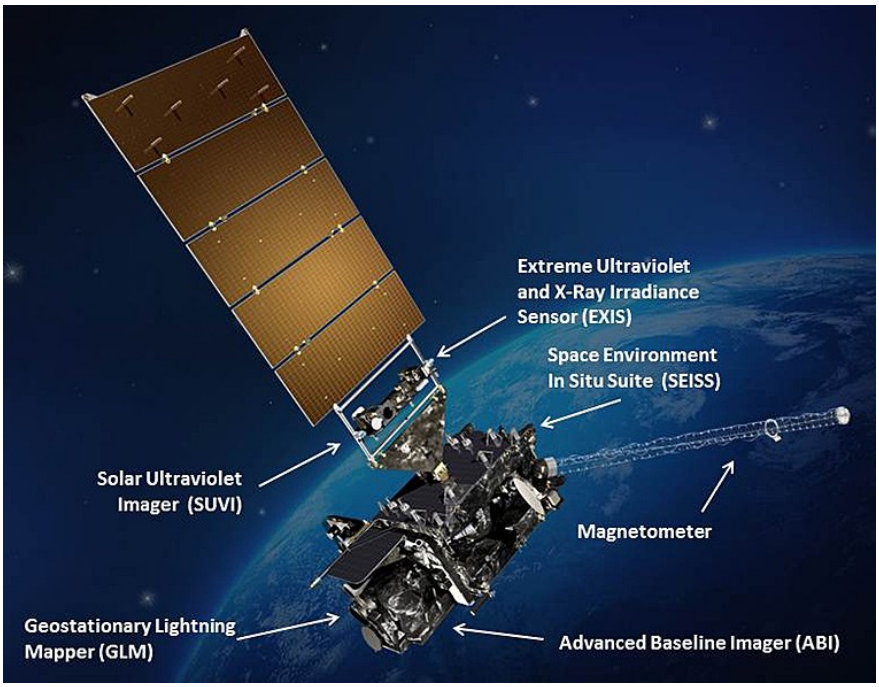
## Newly Launched Satellite to Improve Forecasts—continued

targeted information to local officials to decide if an evacuation is necessary," said Craig Fugate, administrator of FEMA.

GOES-16 is flying six new instruments, including the first operational lightning mapper in geostationary orbit. This new technology will enable scientists to observe lightning, an important indicator of where and when a storm is likely to intensify. Forecasters will use the mapper to hone in on storms that represent the biggest threat. Improved space weather sensors on GOES-R will monitor the sun and relay crucial information to forecasters so they can issue space weather alerts and warnings. Data from GOES-16 will result in 34 new, or improved, meteorological, solar and space weather products.

"We've crossed an historic performance threshold with GOES-R," said Stephen Volz, director, NOAA's Satellite and Information Service. "NOAA is now operating the most sophisticated technology ever flown in space to help forecast weather on Earth."






**NASA Technicians build and prepare GOES-R for launch (above). The GOES-R spacecraft (rendered) and its main components (left).** *NOAA*

There are four satellites in the GOES-R series: -R, -S, -T and -U, which will extend NOAA's geostationary coverage through 2036.

"NOAA and NASA have partnered for decades on successful environmental satellite missions," said Sandra Smalley, director of NASA's Joint Agency Satellite Division, which worked with NOAA to manage the development and launch of GOES-R. "Today's launch continues that partnership and provides the basis for future collaboration in developing advanced weather satellites."

Beyond weather forecasting, GOES-R will be part of SARSAT, an international satellite-based search and rescue network. The satellite is carrying a special transponder that can detect distress signals from emergency beacons.

Additional GOES-R satellite information, including numerous educational videos, is available at **www.goes-r.gov**.

# Quarterly Summary by Tina Stall and James Brotherton

## October

| San Diego - Lindbergh Field Data - October | | | | |
|---|---|---|---|---|
| | Max | Min | Avg | Rain |
| Actual | 77.5 | 63.7 | 70.6 | 0.07 |
| Normal | 72.8 | 62.6 | 66.7 | 0.57 |
| Anomaly | 4.7 | 1.1 | 3.9 | -0.50 |
| % of normal | | | | 12 |
| Max | 91 | 71 | | 0.04 |
| Min | 67 | 61 | | |

The month of October began with an upper-level low pressure trough moving through the western states, bringing gusty winds, cooler weather, and a deeper marine layer through the 5th. Weak high pressure through the 9th brought warming and some gusty offshore winds at times. Onshore flow began increasing on the 10th with a weak shortwave, followed by a larger upper-level trough sitting nearly stationary along the West Coast. Despite transient weak high pressure on the 14th, this pattern maintained cooler weather, breezy winds and extensive marine layer clouds through the 17th. Stronger high pressure aloft built in over the Southwest on the 18th for much hotter, drier weather with gusty northeast winds at times through the 21st.

An impressive lightning show in San Clemente was captured on 24 October. (Khristian Snyder)

A trough of low pressure moved through the region on the 23rd and 24th, bringing up moisture from the south and producing scattered showers and a few thunderstorms to northern areas of the region, with light showers to the south. The main line of showers and embedded thunderstorms was oriented southwest to northeast from Orange County through the Inland Empire and into San Bernardino County, training over this area for most of the day and night of the 23rd. Two-day rainfall totals for San Diego County were mostly one-quarter of an inch or less. Areas north received around one-quarter to three-quarters of an inch, locally up to one inch on the coastal slopes of the mountains. Minor street flooding was reported near El Toro and Highway 247 at Larrea Road. This event was also notable for the high number of lightning strikes over both land and water, totaling over 3100 strikes.

Fair and warmer weather returned under weak high pressure aloft through the 26th, before another upper-level low brought more cooling and breezy conditions with a few very light sprinkles on the 28th. Cool and dry weather continued for the remainder of the month.

Average monthly temperatures were mostly two to four degrees above normal for October.

## Quarterly Summary—continued

### November

| San Diego - Lindbergh Field Data - November | | | | |
|---|---|---|---|---|
| | Max | Min | Avg | Rain |
| Actual | 74.7 | 57.0 | 65.8 | 0.61 |
| Normal | 69.0 | 53.6 | 61.3 | 1.01 |
| Anomaly | 5.7 | 3.4 | 4.5 | -0.42 |
| % of normal | | | | 60 |
| Max | 96 | 63 | | 0.17 |
| Min | 64 | 47 | | |

The month of November began very dry and warm due to pronounced offshore flow and unusually strong high pressure during the first two weeks of the month. Record high temperatures were reached in several coastal and valley locations. San Diego reached a record high temperature of 96 on November 9th. During the latter half of the month, conditions were closer to normal, with cooler weather and a couple of precipitation makers.

The first weather system arrived on November 20th and 21st. This storm brought significant precipitation to much of the region, although no especially heavy precipitation occurred. Coast and valleys picked up between 0.25 to 0.50 inches, while the mountains picked up between 0.5 to 1 inch of rainfall. Totals were a little higher in the San Diego County Mountains with a few spots picking up over 1 inch. There was also a bit of snow in the higher mountains, with 1 to 3 inches in the San Bernardino Mountains.

A rather cold upper level low pressure trough brought a smattering of weather to SoCal between November 26-28, the Thanksgiving holiday weekend. Light to moderate rain occurred across the coast and valleys, generally between 0.25 to 0.75 inch amounts. In the mountains, rainfall totals were 1 to 2 inches, with amounts over 2 inches in the San Diego County Mountains, such as Julian with 2.38 inches and Lake Cuyamaca with 2.79 inches. Since this was a colder storm system, significant snowfall occurred in the mountains, with up to 6 inches in the Big Bear area, 3 inches in Wrightwood, Running Springs, and Lake Arrowhead, and 1 inch at Mt Laguna and Palomar Mountain. The snow caused some traffic headaches in the Big Bear area, and strong winds were reported in the mountains, although there was no significant damage reported. Mountain snowfall caused some traffic delays. Cool but dry weather then persisted for the remainder of the month.

Average monthly temperatures were generally 2.5 to five degrees above normal for November.

### December

Rainfall during the month of December generally saw a substantial increase compared to November, with most areas in receiving well-above normal rainfall. Additionally, water year-to-date totals in many locations were running above normal by the end of the month. There were quite a few rain events during the month. The first was the 7th to the 8th followed by a light drizzle event on the 10th.

A deep low pressure system arrived on December 15th and brought a period of moderate to heavy precipitation to the area. This storm event featured anomalously high precipitable water and moderate wind flow into the mountains. The heaviest precipitation occurred in the San Bernardino and Riverside Mountains, and also near Palomar Mountain

## Quarterly Summary—continued

in San Diego County. A flash flood watch was issued on the 14th followed by one urban and small stream flood advisory, however there were no reports of flooding during this rain event.

Later in the month there was a minor rain event on the 21st to 22nd. A low pressure system from the northwest brought locally heavy rainfall to the region with scattered showers from the 23rd to the 25th. The heaviest rainfall occurred on the 23rd during the night. Strong and gusty winds also occurred mainly in the mountains and deserts on the 23rd and 24th with briefly strong winds at the coast. A flash flood watch was issued on the 22nd followed by numerous urban and small stream flood advisories. There were several reports of flooding in the high desert on the 22nd, followed by one additional flooding report early on the 24th in Suburban Orange County. However, none of the reports of flooding were severe. Average monthly temperatures were one to three degrees above normal for December.

**San Diego - Lindbergh Field Data - December**

| | Max | Min | Avg | Rain |
|---|---|---|---|---|
| Actual | 66.3 | 51.5 | 58.9 | 4.22 |
| Normal | 64.7 | 48.4 | 56.5 | 1.53 |
| Anomaly | 1.6 | 3.1 | 2.4 | 2.69 |
| % of normal | | | | 275 |
| Max | 83 | 59 | | 1.20 |
| Min | 58 | 41 | | |

Strong offshore wind damage in Irvine Park in eastern Orange County on 2 December. (Dan Gregoria, NWS Forecaster)

## Aloha O'e to Tina Stall

Tina Stall has moved up and out to become a forecaster at the NWS forecast office in Honolulu, Hawaii.

Tina arrived at NWS San Diego as an intern in late 2008 and quickly began making significant contributions to our forecast team and programs. For many years she collected storm data to include in the official Storm Data record. She was the assistant Hydrologist, which included work in maintaining our hydrology database of rain gauges and stream gauges. This job also had her writing the monthly weather summaries that we enjoy in this publication. Tina also was the assistant climate focal point, receiving training and education in order to help the climate focal point communicate climate issues to partners and public. She also contributed to the cooperative climate program and the upper air program. On a daily basis, Tina was on the front lines of communication in our public service unit collecting and publishing weather data, and answering questions from partners, media, and the public. For the last few years, she was trained and became proficient on the public and marine/aviation forecast desks.

Tina will be missed personally and professionally by all of us here at NWS San Diego, and we all wish her the best in her new exciting adventure in a tropical paradise.

## Departures and Arrivals—continued

## Derek Shroeter Arrives by Roger Pierce

The newest staff member here in San Diego is Derek Schroeter! Derek is a "Pathways Student Employee", currently working on his Ph.D, in Climate at the University of Delaware, while working here at the San Diego office in the public service section. Derek is originally from Maine, but has been working on his education at the University of Delaware and has also worked here in California in the past. Derek loves the climate of SoCal, but also, coming from a more northern climate, enjoys snow as well! So, our San Bernardino Mountains in our northern County Warning Area is a quick drive away to see snow and get in some skiing, especially this year as several feet have fallen! Derek has a great and broad education background in meteorology and climatology and will be a great addition to the staff working to help foster further climate education, outreach and provide climate decision support services.

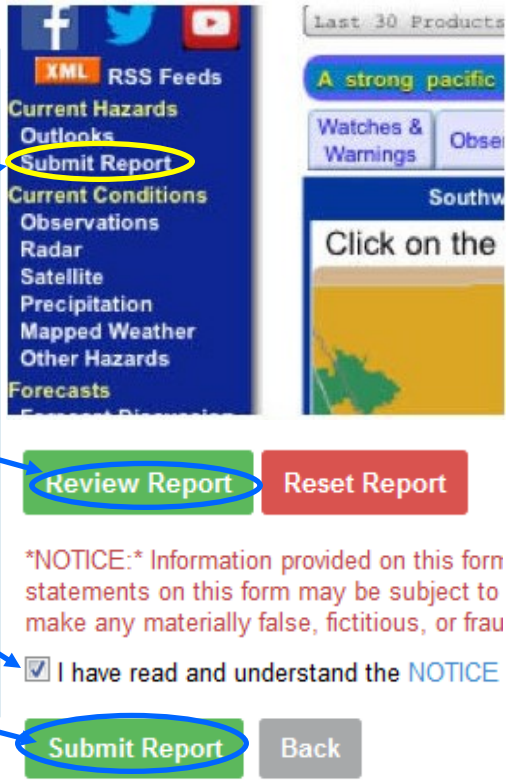
## A Letter from Departing Meteoroligist-in-Charge, Roger Pierce

I would like to express my thanks to all the cooperative observers, storm spotters, and friends of the National Weather Service over the last 5 ½ years that I have been the Meteorologist in Charge here in San Diego. Your weather observations, reports, and interest in the weather forecasting of the NWS are critical to our being able to forecast and warn people of weather hazards. I will be moving on in the next few weeks to a new assignment in the NWS. I will be helping NOAA and 11 other government agencies as the Federal Liaison to the Western States Federal Agencies Support Team (WestFAST) to coordinate and work better together to improve water forecasting and the use of water resources in the Western United States. The last 5 or more years of drought in the west is a true wakeup call that we must be ever vigilant to use our water resources wisely and step up our work at better forecasting the availability of water. I look forward to this new challenge, but will miss all the great people involved in the weather forecasting process here in SoCal. My replacement, hopefully will be onboard soon here in San Diego. Alex Tardy, Warnings and Coordination Meteorologist will be filling in as acting Meteorologist in Charge in my absence.

## News for Partners and Volunteers

We really need and really appreciate the weather reports and ground truth received from our trained weather spotters. Unfortunately, in a few cases these reports haven't made it to our forecasters in a timely manner because the final step in submitting the report wasn't made. We understand it can be a long time between reports for many spotters and the reporting form can become unfamiliar. Here's a quick review of the process:

1. Get on weather.gov/sandiego.
2. Click on "Submit Report" at upper left menu. (You may want to bookmark this link).
3. Fill in steps 1, 2, 3 and 4 on the page
4. At bottom, click on "Review Report". (That will take you to the next page.)
5. Review your report. When ready, check the box "I have read and understand the NOTICE".
6. Click on "Submit Report".




***Thank you for your timely, quality reports!***

Coast to Cactus Editor: Miguel Miller, miguel.miller@noaa.gov

NWS San Diego Weather Spotter Program Manager: Alex Tardy, alexander.tardy@noaa.gov

Contributors to this issue: Derek Schroeter, Tina Stall, James Brotherton, Alex Tardy

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Spotter reports online: http://www.srh.noaa.gov/StormReport/SubmitReport.php?site=sgx

**Photos are always welcome!** Please send them to: sgx.forecasters@noaa.gov Be sure to include: Name of photographer, where and when it was taken, a brief description of photo, and if we have permission to use it for official purposes.

Weather Spotter web site: www.wrh.noaa.gov/sgx/spotter/spotter.php

(*Coast to Cactus* can always be found on this page.)

Southwest California Skywarn© web site: swskywarn.org , e-mail: swskywarn@swSkywarn.org

Change of: Address (email or home)? Phone numbers? Equipment?, etc. Please email Alex Tardy with the changes. alexander.tardy@noaa.gov.